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Agricultural Research

Commandeering Insect Communications

Nature's Ma Bell—Molecular Messengers

Some interesting facts about pheromones, hormones, and messenger peptides surfaced at a conference cosponsored by ARS last spring. If one looks hard enough, one can find these biochemicals in all living things, from the single-celled bacteria and yeasts to the flowering plants, and from the single-celled protozoa to humans. Underlying their chemical diversity and their broad distribution is the fact that all are used as messengers.

Pheromones allow one organism to communicate with another, locally or long distance. (See story on insect pheromones, p. 8.) Hormones and messenger peptides constitute the intercom system—relaying messages among cells, tissues, or organs within an organism. The messenger peptides—short chains of amino acids—link the endocrine, nervous, and immune systems with one another and with the rest of the body. Why, then, are insulin and other hormones, as well as a fair sampling of the messenger peptides, turning up in the likes of single-celled protozoa, fungi, and bacteria?

Says Jesse Roth of the National Institutes of Health: "We think that many of these messenger peptides have arisen in unicellular organisms evolutionarily, and they are widespread because that's where they began."

It seems that insulin—the hormone that regulates the metabolism of blood sugar—is being found throughout the animal and plant kingdoms. Chemically speaking, it also happens to be a peptide. Protozoa produce insulin that can stimulate blood sugar metabolism in vertebrates, Roth says. And its effect can be neutralized with vertebrate antibodies to insulin. When clams and their relatives are given glucose, cells in their gastrointestinal tracts release insulin. "You can make a mollusk diabetic," he says, "by giving it [a vertebrate-produced] antibody against insulin." Blowflies apparently also secrete insulin from a small group of cells just above their brains, he continues. If the cells are removed surgically, the insects go into a diabetes-like state.

An insulin-related chemical has also been found in higher plants that is similarly active in vertebrates. So far, says Roth, higher plants are known to contain all of the classes of vertebrate hormones and other hormone-like substances, at least one of the human brain peptides, and chemicals related to the infection-fighting interferons. In fact, he notes, vertebrate interferon helps tobacco plants fight virus infection.

Among the vertebrates themselves, the hormones—once thought to be secreted only by the endocrine glands—are increasingly being found in unconventional places. And nonhormonal growth factors, immune system peptides such as the interferons, and many other chemical messengers behave like hormones but are produced at many sites in the human body. "It's just a quirk of fate that [insulin] would first show up as a hormone," says biochemist Candice Pert of the National Institute of Mental Health. "It's really a neuropeptide."

Perhaps the simple brewer's yeast, *Saccharomyces*, best underscores Roth's hypothesis that messenger peptides began as pheromones. The yeast emerges from its spore stage as two types—alpha type and "a" type—each having half the full complement of chromosomes. Before these types can fuse, each type produces a pheromone that binds to a receptor on the membrane of the other type. Experiments have shown that the pheromone produced by the alpha type is so similar to the mammalian hormone that "instructs" the pituitary gland to stimulate the production of eggs or sperm that it causes the same response in rats.

With all this confusion in terminology, it's not surprising that an old debate on plant hormones has resumed. Tony Trewavas, a plant scientist at the University of Edinburgh, is questioning whether plant hormones are in any way analogous to animal hormones. Textbooks define hormones as substances produced at a specific site and transported by the blood to a distant site where they produce a response. He further denounces techniques for studying plant hormones based on the assumption that they operate like animal hormones. (See *New Scientist,* May 17, p. 9.)

Trewavas finds no hard evidence that the so-called plant hormones are transported from one part of a plant to another. Many changes in one part of the plant that are correlated with changes in another part can be explained by the different parts competing for resources such as nutrients and sunlight, he says. He cites mathematical models that do not require a "hormonal component" to account for some of the interactions between plant parts. Moreover, plants are not as differentiated as animals into distinct tissues and organs under a centralized control system that depends on communication networks. Thus, the "target cells" concept of a hormone is less relevant to plants.

Instead, Trewavas proposes that the classes of chemicals now called plant hormones help to "smooth out" the variations in nutrients and light rather than play a lead role in governing plant development.

Jerry D. Cohen of ARS' Plant Hormone Laboratory, Beltsville, Md., suggests that Trewavas is trying to make positive conclusions from negative data. According to Cohen, Trewavas bases his arguments on traditional studies of plant-hormone interactions where the amount of hormone applied to a plant tissue appears much higher than its concentration within the reacting tissue. In recent studies, however, where scientists have been able to isolate the reacting tissue, the differences disappear, he says. Tissue from the inactive sites had muddied the measurements.

Cohen says that a number of studies, including his own, confirm that plant hormones are produced in certain tissues and are transported to the growth sites. While nutrients and light play a major role in plant growth and development, he says, "the fine tuning has to be under some internal control. The best evidence is that it is hormonal."

For more on this debate, see the October 1983 issue of *Trends in Biological Sciences* (vol. 8, no. 10), p. 354.

J. L. M.

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Cover: Tiny red imported fire ants (about 6 mm in length), scourge of livestock and humans in the South, crawl on a blade of grass at the Insects Affecting Man and Animals Laboratory, Gainesville, Fla., Researchers here and around the country are studying how these and other insect pests "talk" to one another through pheromones. Ultimately, they hope to turn insects' own chemical communication systems against them. Story begins on page 8. (1084X1630-13A)

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Toxoplasmosis Causing Abortions in U.S. Sheep Flocks

It is now confirmed for the first time that a microscopic parasite causes widespread sheep abortions in the United States.

Scientists have traced abortions in 16 flocks of sheep in Iowa, Maryland, Montana, Minnesota, and South Dakota to the parasite *Toxoplasma gondii,* which causes one-time abortions in sheep, says microbiologist Jitender P. Dubey, Beltsville, Md.

"Up to now, toxoplasmosis-induced abortions have been reported in only one other case," Dubey says.

The parasite is well known as a cause of sheep abortions in other countries, he says, but until recently it was not considered a problem in U.S. sheep flocks.

How long toxoplasmosis has been causing sheep abortions in the United States is hard to estimate, Dubey says, because its symptoms are similar to those of other diseases. Symptoms include loss of appetite, weakness, and difficult breathing.

Dubey says that for a ewe to abort from toxoplasmosis she must contract it when she is pregnant. After the first infection the ewe will not abort again, even if reinfected.

The ewe's immune system controls the growth of the parasites, the researcher says. The organisms remain in the body tissues as cysts, where they cause no further harm.

Dubey says livestock producers may needlessly cull ewes that lose lambs, believing the animals have an inherited tendency to abort. Often, valuable breeding stock mistakenly are sent to slaughter after they have become resistant to the disease, he adds.

Confirmation of toxoplasmosis-caused abortions in five states has led to a cooperative agreement between ARS and South Dakota State University, Brookings, to monitor sheep flocks in that state and two adjacent states to determine the extent of the problem.

Dubey says grass-eating animals, such as sheep, contract toxoplasmosis by eating oocysts, the egg-like form of the parasite, in feed or water. Cats—from family pets to the Siberian tiger—are the only animals known to pass on the parasite in their feces, he says. They contract the parasite from eating other infected animals. Once cats leave the oocysts in the soil, they are spread by rain, earthworms, cockroaches, and flies into the feed or water sources of sheep. Oocysts may live for months in moist soil. Humans can contract the parasite by eating infected meat or ingesting the oocysts.

No effective vaccine or cure for toxoplasmosis is known, but Dubey has discovered a harmless parasite that may help scientists find a control for the disease in sheep.

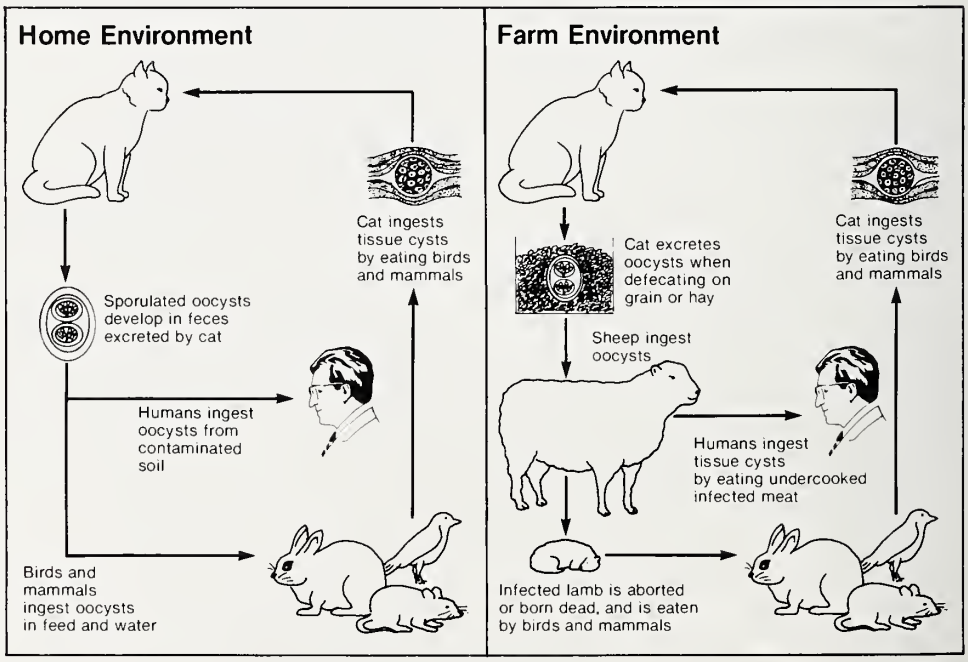
He says the parasite, *Hammondia hammondi,* when injected into laboratory hamsters, mice, and goats, prevented serious toxoplasmosis infections. The parasite itself cannot be used in this country to control toxoplasmosis, he says, because the U.S. Food and Drug Administration will not approve the use of a live parasite vaccine.

Dubey says he is cooperating with the Tasmania Department of Agriculture in Australia to test the overall effectiveness of using the parasite to protect sheep against toxoplasmosis.

If the Tasmanian research does immunize sheep, he says, ARS will try to isolate the specific protein in the parasite that is responsible for creating the immunity. Private industry could then use the technology to develop a vaccine.

White patches of dead tissue on placenta expelled from a ewe after aborting a fetus indicates the presence of toxoplasma. (PN-7136)

Jitender P. Dubey is located at the Animal Parasitology Institute, Bldg. 1040, Beltsville Agricultural Research Center—East, Beltsville, Md. 20705.—**Vincent Mazzola,** Beltsville, Md. ■



PN-7139

Genetic Switch Upgrades Soybean Protein

A way to turn on and off a gene in soybeans has been discovered by ARS scientists who say the research could lead to increasing the nutritional value of soybeans and other legumes.

The researchers say they can manipulate the gene that increases or decreases the content of a vital amino acid in soybean protein. The nutritional value of soybeans and other legumes is now limited by low amounts of the amino acid methionine.

Discovery of the genetic switch opens the way to raise the methionine content of soybean protein, thereby making it more nutritionally complete, according to plant physiologist John F. Thompson and chemist James T. Madison at the U.S. Plant, Soil, and Nutrition Laboratory, Ithaca, N.Y.

Such an accomplishment would benefit that part of the world's population that relies on soybeans, peas, beans, and other legume crops to meet daily protein needs.

The genetic on-off switch was discovered by a research team headed by Thompson and Madison. They and plant physiologists Lorraine P. Holowach and Gary L. Creason, who is now with the E.I. duPont de Nemours Co., have been investigating how "storage proteins" are formed in soybean seeds.

Storage proteins, Thompson explains, make up two-thirds of all protein in the seed, and are the proteins that are used to make meat extenders and other soy protein foods.

Seeds growing in nutrient solution as well as those attached to plants were studied. When the research team added methionine to the nutrient solution, they found that formation of protein methionine increased by one-fifth.

To determine why protein methionine levels rose, the scientists focused on two storage proteins, glycinin and conglycinin. They found that methionine added to the culture medium prevented formation of a portion of conglycinin known as the beta subunit. This lowers the seed's conglycinin content, which is then replaced by an equivalent amount of glycinin. Because glycinin is richer in methionine than conglycinin, the end result is a higher percentage of methionine in the seed's storage protein, Madison explains.

Plant physiologist Lorraine Holowach (above) selects immature soybean seeds that will be split and placed in a culture medium with a small amount of the amino acid methionine. (1084X1596-28) She and colleague John Thompson, also a plant physiologist, examine the cultured seeds. (1084X1596-33)

Subsequently, the team showed that methionine inhibits formation of the beta subunit's messenger RNA. Messenger RNA's provide the information necessary for cells to manufacture protein.

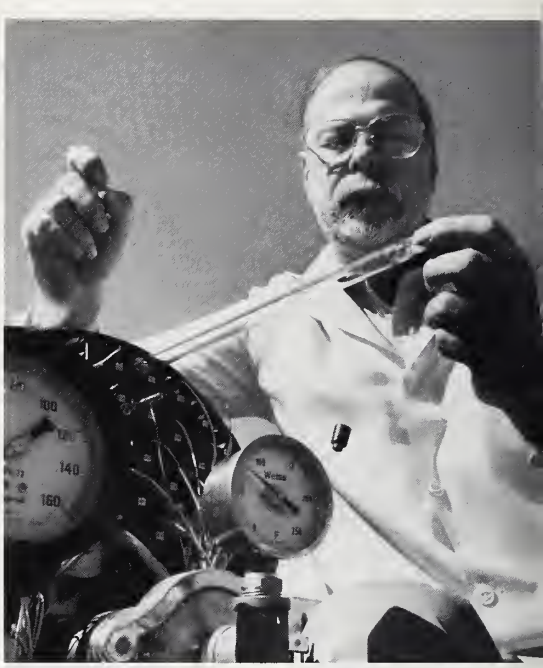
Thompson noted that scientists at the University of Missouri have injected methionine into stems of soybean plants and achieved results similar to those the ARS team observed in culture.

While it is not economically feasible to directly treat plants with methionine, Thompson says, fuller understanding of the basic physiological mechanisms could lead to soybean varieties having more nutritious protein.

In addition, from a scientific standpoint, learning how methionine inhibits the expression of one specific soybean gene provides a research system that may be a key in further study of gene expression, the scientists say.

John F. Thompson, James T. Madison, and Lorraine P. Holowach are located at the U.S. Plant, Soil, and Nutrition Laboratory, Tower Rd., Ithaca, N.Y. 14850—**Russell Kaniuka** and **Lloyd McLaughlin,** Beltsville, Md. ■

Mobile Disposal Method for Pesticide Wastes



Above: Research assistant Mark Muldoon adds pesticide waste from Beltsville farm operations to the mobile unit holding tank. (0984X1519-13A)

Right, top: Chemist Philip Kearney inspects one of 66 tubes that generate ultraviolet radiation through the chemicals as they pass through the system. (0984X1520-27A)

Right, bottom: In studies of bacteria that degrade pesticides, microbiologist Jeff Karns examines an *Achromobacter* species isolated by Beltsville chemists. The species proved successful in degrading Furadan®, an insecticide used on corn. (0684W965-3)

Chemical breakdown of 2,4-D, atrazine, paraquat, and other agricultural chemicals was dramatically improved in tests of a new, portable disposal method at the Beltsville Agricultural Research Center, Beltsville, Md.

The method exposes liquid pesticide waste to two treatments. First, the combined action of high-energy ultraviolet (UV) light and oxygen loosens strong molecular bonds, rendering most pesticide compounds more biodegradable. The partially decomposed waste then goes into a disposal tank of soil and gravel for further breakdown by microorganisms.

Farmers, commercial pesticide applicators, and small-scale manufacturers and wholesalers who handle pesticides could benefit from the new method, according to Philip C. Kearney of the

Pesticide Degradation Laboratory, Beltsville, Md.

In tests of the method, scientists mounted a large UV treatment apparatus onto an 18-foot trailer, thereby making the method portable.

Costs for purchasing and operating the mobile disposal method are lower than costs of incinerating toxic wastes but may not be as economical as some current land-disposal methods. However, the mobile method would simplify the handling of pesticide wastes, particularly at remote places where transportation to proper waste disposal locations is difficult or expensive.

"We have only tested the method so far for environmentally sound disposal of chemicals in agriculture—our own 'backyard,'" says Kearney. "But, we are eager to test it in cooperation with researchers from other industries."

Complete data are not available on the magnitude of pesticide wastewater generated annually in the United States, says Kearney. Roughly half of all pesticides used in this country, for example, are applied to croplands and forests by commercial aircraft. Each of some 10,000 aircraft may create 10 to 60 gallons of diluted pesticide waste each day through mixing operations and excess from spray tanks that needs to be disposed of.

With the new method making it easier for soil microbes to detoxify hazardous wastes, Kearney and coworkers have turned to research for improving the microbes' appetites.

The scientists are currently trying to develop super-digesting microbes, both through selection of the best performing microbes and through genetic engineering.

Philip C. Kearney is located at the Pesticide Degradation Laboratory, Bldg. 050, Beltsville Agricultural Research Center—West, Beltsville, Md. 20705.—**Stephen Berberich,** Beltsville, Md. ■

Getting the Most Out of Grain Supplements

Cows on the range at Miles City, Mont. (0782X833-14A)

Because grain supplements can be a relatively expensive component of range cattle diets, scientists are seeking ways to ensure that cattle make maximum use of both supplements and forages for efficient weight gain.

Range nutritionists Rex Kartchner and Don C. Adams, Miles City, Mont., found that pregnant cows gain weight faster and generally improve in body condition if fed grain supplements daily, rather than every other day. They also found that steers gain best if fed in the afternoon, rather than in the morning.

Feeding daily vs. every other day. . .

The cows grazed native range during the study, which ran from early November through mid-January. One group was fed cracked corn every day; another group was fed twice the daily amount every other day, so both groups received the same amount during the study.

Although eating so much grain at one feeding didn't make the cows on the alternate-day schedule sick, it did reduce their weight gain by almost half. Furthermore, the research demonstrated that the lower weight gain of these cows negated any savings from reduced labor and equipment costs. The scientists think that feeding small grains such as barley, oats, or wheat would produce similar results.

In addition, the scientists found rumen samples taken from steers on an alternate-day feeding schedule to have less favorable conditions for forage digestion than that of steers fed daily.

Feeding in the morning vs. afternoon. . .

Adams and Kartchner, who is no longer with ARS, found that yearling steers gained about 30 percent more if they were fed at 1:30 p.m. rather than the more traditional time—8:30 a.m.

"It appears that feeding supplements in the morning disrupts their normal grazing activity and slows gains," says Adams.

Steers supplemented in the morning spent more time grazing each day but consumed less forage than either steers not supplemented or steers supplemented in the afternoon, Adams says. Morning-fed steers probably spent more energy to actually consume less forage than did other steers in the study.

"Additional research is underway to determine if this effect is noticeable for cows, for cattle grazing other types of pastures, and during other times of the year," says Adams.

Don C. Adams is located at the Fort Keogh Livestock and Range Research Laboratory, Rt. 1, Box 2021, Miles City, Mont. 59301.—**Dennis Senft,** Albany, Calif. ■

Pheromones— Decoding Insects' Chemical Communication

Chemist James H. Tumlinson observes a captive female tobacco hornworm moth "calling" for a mate by releasing her sex pheromone. Tumlinson collects the pheromone to analyze its chemical makeup by chromatography. Because the pest is nocturnal, the studies take place in a room darkened to simulate night. The photograph was taken with a split-second strobe that did not disturb the moth. (PN-7138)

Since the sex pheromone of the silkworm moth (*Bombyx mori*) was first identified 25 years ago, chemists and entomologists have been working feverishly to break the chemical code of insect communication. To date, they have identified and synthesized the sex pheromones for some 335 insect species, including many of the major crop pests, says May Inscoe, a chemist with the Organic Chemical Synthesis Laboratory, Beltsville, Md.

Sex pheromones are usually emitted by female insects to attract males of the same species, although some are emitted by the males, and still others require chemical components from both sexes and occasionally even from a host plant to consummate the courtship.

For roughly 500 species, research has also turned up sex attractants that may or may not turn out to be pheromone components, says Inscoe, as well as a fair share of pheromones that insects use for other purposes.

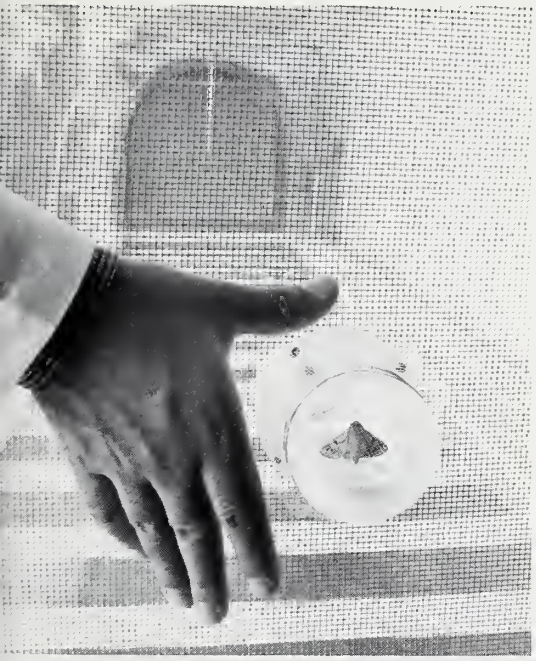
For instance, some aphids and ants, when attacked by predators, produce alarm pheromones that scatter fellow members much like a fire alarm sends people scurrying from a building. Some weevils dispense aggregation pheromones that get the gang together when one finds a suitable spot to feed and lay eggs. A fruit fly may use a pheromone to mark the fruit in which she deposited an egg to deter other females from laying an egg in the same fruit. This allows each developing offspring a fruit to consume by itself. Worker ants use pheromones to mark trails to a source of food so that their sisters can find it, and the brood-tenders recognize the queen ant by her own special pheromone.

The more scientists probe insects' sense of smell, the more complicated the picture gets. "Our appreciation of the sophistication of insect chemical communications systems has greatly increased over the last 20 years," says James H. Tumlinson, leader of chemistry research at the Insect Attractants, Behavior, and Basic Biology Research Laboratory, Gainesville, Fla. He compares it with the human language: "Just as words may mean different things to different people or have different contextual meanings... the message that a particular pheromone transmits depends on the antenna that receives it and the environment in which it is received." Tumlinson has been one of the pioneers of insect pheromone research and was recently named ARS's Scientist of the Year for his many contributions to this field.

In a 1969 landmark study, Tumlinson showed that the male boll weevil (*Anthonomus grandis grandis*) produces a four-component aggregation pheromone. Since then he has been involved in unraveling the mysteries of pheromone communication for more than 20 insect species, most of them agricultural pests.

Caught in the Tender Trap

To determine the single-component pheromone of the gypsy moth (*Lymantria dispar*) in 1970, chemists at Beltsville's Organic Chemical Synthesis Laboratory (OCSL) used 400,000 virgin



At Beltsville, Md., a male corn earworm moth is placed in the mouth of a flight tunnel (top photo) to demonstrate that the synthetic pheromone has the correct number of components in the correct ratios. This is necessary to elicit all the steps that normally occur in the premating ritual. (1084W1577-2). When a man-made breeze carries the scent from the other end of the tunnel, the male moth flies upwind, lands on the pheromone-treated paper strip, and begins his mating dance. (1084W1577-26A)

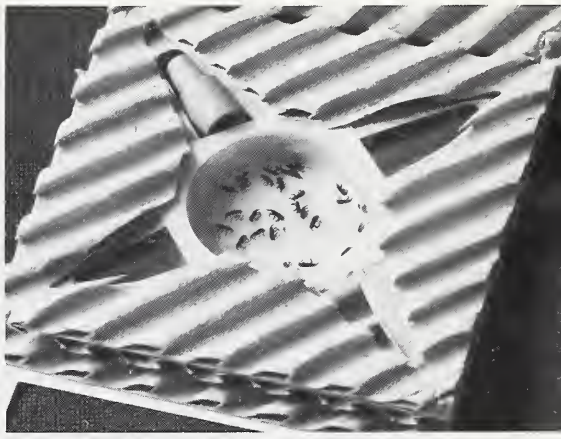
females to get enough material to analyze, says Barbara Leonhardt. The availability of highly sophisticated instruments and new techniques developed by Leonhardt, Tumlinson, and others now allow chemists to identify the chemicals in a pheromone at billionths of a gram. Leonhardt's colleagues, entomologist Jerome Klun and his coworkers, recently identified the four components of the western bean cutworm (*Loxagrotis albicosta*) pheromone with just four insects. He and other members of the OCSL have participated in deciphering the pheromones for at least 30 insect species, including the corn earworm (*Heliothis zea*) and its close relative, the tobacco budworm (*H. virescens*). Insects are so sensitive to these signals that they can detect concentrations of a few hundred molecules in a cubic centimeter of air, he says.

Because of these advances, pheromones or pheromone-like lures for close to 100 insects are now commercially formulated as trap baits to help scout for insects and estimate their numbers. This allows farmers and pest management specialists to restrict pesticides to the infested areas and to time applications so that they coincide with the damaging stage of the pest. Pheromones are also helping scientists study insect behavior and follow their migrations, Klun says.

The discovery of pheromones and the development of new and better traps have gone hand in hand. At the Stored Products and Household Insects Laboratory, Madison, Wis., entomologist Wendell E. Burkholder designed two traps—a cardboard trap and a plastic probe—that are effective in detecting insects in warehouses or grain bins.

All grain insects together account for a 5- to 10-percent loss of stored grain in the United States, according to Burkholder, but the weevils and borers are the most serious pests because they break into the kernels. The others are often indicators of grain that is going out of condition because they usually feed on damaged and broken kernels.

Commercial food processors are now using the traps to monitor insect populations, he says, and one pest-control consultant is recommending the cardboard trap as a possible replacement for spot fumigations with ethylene dibromide (EDB) in flour mills. (See p. 16 for information on pending patent.) EDB was recently banned for



Adult grain weevils *(Sitophilus spp.)* suffocate in the oily food lure in this corrugated cardboard trap. An aggregation pheromone emanating from the V-shaped notches also helped attract them there. The trap, developed by Wendell Burkholder and former University of Wisconsin student collaborator Alan Barak at Madison, Wis., can effectively control stored-grain insects without the use of insecticides. (0983X1312-3)

use as a fumigant on grains.. Both traps now use a highly attractive food lure—a mix of wheat germ and oat oils blended with mineral oil for consistency. Adding the pheromone of the problem insect would enhance the potential of using the traps in lieu of fumigants, he says.

According to Burkholder, pheromones have been identified for nearly all of the important stored product pests—19 of them at last count. The confined space and uniform habitat of storage warehouses "lend themselves favorably to insect management by pheromones," he says. Working with colleagues Joel Phillips and Catherine Walgenbach at Madison, Burkholder identified the aggregation pheromone of the rice weevil (*Sitophilus oryzae*). It turned out to also be the pheromone of the maize weevil (*S. zeamais*) and works well in aggregating male and female granary weevils (*S. granarius*). (See *Agricultural Research,* Nov/Dec 1983, p. 10.) The fact that the pheromone attracts both sexes makes it potentially even more useful for pest control.

A special trap designed by scientists at the Boll Weevil Research Laboratory, Mississippi State, Miss., and the pheromone discovered by Tumlinson are helping growers in North and South Carolina in efforts to eradicate the boll weevil.

The Boll Weevil Research Laboratory

During the current boll weevil eradication program in the Carolinas, ARS entomologist Bill Dickerson (center) inspects the pheromone dispenser from a trap held by program supervisor Elizabeth O'Briant of the North Carolina Department of Agriculture. Looking on is cotton producer Donnie Lewis, who is cooperating with ARS, APHIS, and the state in the program. (1084X1640-9)

scientists have worked closely with private and government cooperators on the Carolina eradication program, now in its second year, according to laboratory director Ed Lloyd. They have developed a high-powered, pheromone-dispensing trap, and they know where and when to deploy the traps to locate any weevils that may be lurking about.

The boll weevil pheromone trap was a very important tool for use for both detection and suppression in an eradication trial conducted on about 40,000 acres of cotton in northeastern North Carolina in 1978 to 1980. The trial resulted in about a 70-percent reduction in insecticide use and helped to control very low level populations by catching males and females as they emerged in spring before they had a chance to mate. This program has now been expanded to include a total of about 200,000 acres of cotton throughout North and South Carolina.

The male-produced pheromone functions both as an aggregation pheromone and as a sex attractant, depending on the season, Lloyd says. In May and June, males find the cotton plants, feed, and produce a pheromone attracting both males and females to join in the feast. By the time the cotton plants fruit in July, thoughts turn to sex. Males ignore the pheromone from other males and keep emitting their own come-hither scent. Females respond to them, mate, and deposit their fertile eggs in the now-ready cotton squares. By September, the burgeoning population has consumed most of the food supply and it's time for males to go scouting again.

Researchers at the Mississippi lab and another ARS laboratory at Florence, S.C., are now so familiar with the lifestyle of the boll weevil that they are providing the technical expertise for the Carolina program. After seeing the results of the pilot eradication trial in northeastern North Carolina, growers in both states voted 3 to 1 to fund a project to banish the boll weevil from the Carolinas. They are paying 70 percent of the costs.

It's A Bug-Eat-Bug World

Getting a beneficial insect to do its job is not as easy as it appears. Scientists at the Insect Biology and Population Management Research Laboratory, Tifton, Ga., have been studying how parasites locate their hosts. While working with the tiny *Trichogramma* wasps, entomologist Wallace J. Lewis observed that the wasps were eavesdropping on the mating signals of corn earworms to determine when and where to deposit their eggs. The wasps use the eggs of the corn earworm and its close relatives as nurseries for their own young—killing the pests' eggs in the process. Lewis obtained hollow fibers containing corn earworm pheromone from Tumlinson. When the Tifton scientists placed the pheromone fibers in Georgia cotton fields, they more than doubled the rate of parasitization of earworm eggs by native wasps.

The discovery may be a breakthrough for biological control. Tumlinson says that laboratory-reared *Trichogramma* wasps have been released in a number of programs to control moths, but success has been spotty because the wasps tend to fly away. "Our idea is to keep them in a moth-infested field with the pheromone," he says.

According to Lewis, the wasps respond to several other stimuli—including colors, plant odors, and other insect chemicals—when searching for a host. And they respond to these stimuli in a specific sequence. He and colleagues want to get a better understanding of the whole sequence so they can use the pheromones with precision. But he admits the discovery opens "exciting possibilities for integrating the use of parasitic insects with mating disruption." Mating disruption is a technique in which the air is saturated with a pheromone to confuse the males as they search for mates.

The inch-long spined soldier bug (*Podisus maculiventris*) also helps to keep

A Mexican bean beetle larva—a devastating pest of snap and soybeans—becomes a meal for the spined soldier bug instead. The bug's pheromone, discovered by entomologist Jeffrey Aldrich at Beltsville, Md., may help farmers enlist its help in controlling many pest insects. (0484W406-3)

As chemist Robert Vander Meer applies their natural trail pheromone to the circle, worker fire ants heed the call to forage for food. Research leader Clifford Loffgren (left), Vander Meer, and their colleagues at Gainesville, Fla., have found that the pheromone contains several components which attract as well as guide ants to a food source. (0484X501-29)

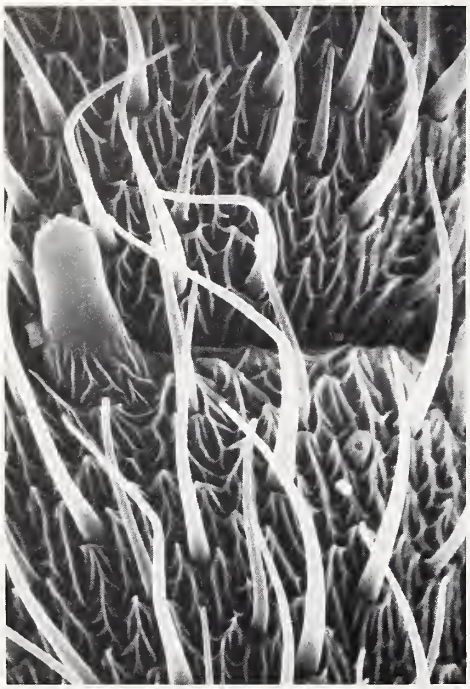
undesirable insects in check. However, instead of parasitizing specific eggs, it feeds on more than a hundred insects, including the corn earworm, the fall armyworm, and the gypsy moth.

The bug—one of several related insects popularly called stink bugs—fortunately prefers dining on the larvae, which generally do the most damage to crops. It inserts its proboscis into its prey like a straw in a soda and sips out the vital juices. Unfortunately, the bug is just as content to dine on nonpest insects and therefore has not been drafted for active service in the perennial war against crop pests. That may change.

At the Insect Physiology Laboratory at Beltsville, entomologist Jeffrey Aldrich identified the soldier bug's aggregation pheromone and found it very effective in attracting both males and females. He predicts that gardeners or farmers could treat infested areas with this pheromone or others like it and thereby lure indigenous predators to feed on unwanted insects. The pheromone is the "first man-made pheromone that attracts an insect predator," he says, and is the first pheromone identified for the insect order Hemiptera—the true bugs. It is a blend of five relatively simple compounds that are commercially available. Such manipulation of insect predators is a novel approach, he says, "and may be a harbinger of our future battle strategies in the never-ending conflict between man and insects."

The Old Bait-and-Switch Routine

Since immigrating to this country more than 60 years ago, the red im-



Hundreds of microscopic sensilla protrude from each segment of a cabbage looper's antenna shown here at 800 times life size. Each sensilla contains one or more neural receptors for the insect's own pheromones and for other odors. SEM by postdoctoral fellow Alan Grant at Gainesville, Fla. (PN-7135)

ported fire ant (*Solenopsis invicta*) has entrenched itself in ten southern states despite numerous efforts to control it. A nest can contain as many as 200,000 inhabitants and rise 3 feet above the ground. When disturbed, the tiny beasts attack livestock and people, leaving bites that burn for hours and occasionally result in death.

At the Insects Affecting Man and Animals Research Laboratory in Gainesville, scientists are looking for ways to get pathogens or conventional insecticides into the heart of the nests. Pheromones might be the answer, says Clifford Lofgren, leader of the fire ant research unit. Working with Tumlinson, they identified components of the queen recognition pheromone—the scent that keeps her attendants attentive. Tests showed that when a nest was disturbed, the brood tenders (the young females) would carry pieces of rubber treated with the pheromone back to the nest, place it near the real queen, and care for it. But the brood tenders normally don't leave the nest. As they age, their ability to respond to the queen pheromone decreases and they assume the role of foraging workers.

Chemist Robert Vander Meer recently identified three components of the worker ant's trail pheromone—the scent they use to mark a path to a food source and summon nearby ants to it. By combining the trail pheromone, the queen recognition pheromone, and a lethal agent with a granular bait, Lofgren expects to get foragers to carry the bait back to the nest where they would lick it and share what they ingest with nestmates. The pathogen or insecticide would thus reach all the ants, including the queen who produces all of the offspring for the colony.

The pheromone-treated bait would reduce the amount of insecticides in the field, because it would be very species specific, says Tumlinson. If carried into the nest, less persistent and more environmentally safe pesticides could be used effectively, he adds.

Lofgren says it will take a year or two more of research to develop an effective pheromone bait. One of the components of the trail pheromone has a unique structure that calls for Vander Meer to develop a new method for its laboratory synthesis.

Where Do We Go From Here?

"Insect sex pheromones are among the most biologically potent natural products around, and, for the moths, we have developed a particularly good understanding of the chemistry involved," says Klun. "However, we don't know much about the biosynthetic origins of these molecular messages, the physiological factors that control their timely release, or the mechanisms by which the insects sense these airborne chemical signals. These are important research challenges, and if we meet them, novel and effective pest control measures may result."

For example, by understanding how insects perceive mate or host odors it may be possible to antagonize their sensing abilities. This would render them incapable of detecting the chemical signals that are so vitally important to their survival.

Scientists know that insects' antennae are equipped with thousands of tiny hairlike projections called sensilla—each having receptors specialized for their own pheromones and a number of other survival scents. The cabbage looper (*Trichoplusia ni*), for instance, has 10,000 sensilla on each antenna, about half of which respond to a restricted range of compounds centering on its own pheromone, says entomologist Sidney Mayer of the Gainesville attractants lab.

Mayer and colleague Richard Mankin are attempting to determine what information actually goes to the insect's brain. "The brain can only respond to signals from the neurons [in the sensilla]," explains Mayer.

By measuring the neural responses in sensilla to pheromone components, they hope to lay the groundwork for understanding how an insect converts a chemical stimulus into a signal and integrates the signals into a message the brain understands. At the same time, they are determining how sensitive a wide range of insects are to their own pheromones by measuring responses to various concentrations.

The sensilla also respond to a host of environmental odors that don't appear to change the insect's behavior. The team discovered this by hooking up tiny electrodes to insect antennae to measure the neural response to environmental stimuli. The results showed that the insects detected humidity and odors from laboratory equipment such as cork, Teflon, and filter paper.

The goal of these research efforts, says Mayer, is to interfere with an insect's perception of a pheromone. "If we could do that, we could prevent the pheromone from eliciting a behavior. We're a long way from finding out what elicits insect behavior, but we've come a long way, too."

May Inscoe, Barbara Leonhardt, and Jerome Klun are located in Bldg. 007, and Jeffrey Aldrich is in Bldg. 467, Beltsville Agricultural Research Center, Beltsville, Md. 20705; James Tumlinson, Clifford Lofgren, and Sidney Mayer are at 1700 S.W. 23rd Dr., P.O. Box 14565, Gainesville, Fla. 32604; Wallace J. Lewis is at the Georgia Coastal Plains Experiment Station, Tifton, Ga. 31793; Wendell Burkholder is at the Department of Entomology, University of Wisconsin, Madison, Wis. 53706; and Ed Lloyd's address is P.O. Drawer 5367, Mississippi State, Miss. 39762.—**Judy McBride,** Beltsville, Md. ■

Slot Machine Pays Off

A newly developed mulching machine may protect erosion-prone farmland from water runoff that strips away topsoil and pollutes streams with sediment.

The machine is a slot mulcher—built on the oldtime farm philosophy of "that which is taken from the land should be returned to the land." In this case it is wheat and barley straw left after harvest that is returned to the land, according to the researcher who pioneered development of the machine.

Keith E. Saxton, hydrologist with the Land Management and Water Conservation Research Laboratory Pullman, Wash., says that in tests with the slot mulching machine annual erosion from cropland was cut to 1 ton or less per acre. "This is a dramatic improvement for Washington's Palouse Hills region where soil losses often run 20 to 30 tons per acre with conventional tillage," he says.

Slot mulching is simple in principle, Saxton says. Small trenches or slots are cut into the field about 12 to 20 feet apart and tightly stuffed with straw. The slots follow the contour of the field so that rain or melting snow running off the field will cross them at right angles. Straw sticking up from the slot slows the water so that soil particles settle out and remain on the field.

Saxton says that compacting crop residues into slots pays off in other ways, too. Water can soak into the soil from the trench even if the ground surface is crusted or frozen. Excess plant residues are disposed of, making it easier to plant the next crop. And eventually the mulch decomposes to provide organic matter to the soil.

Saxton and soil physicist Gaylon S. Campbell of Washington State University's Department of Agronomy and Soils believe fields need only one slot mulching treatment per year. It will be effective until the tops of the slots are buried either by sediment or farm machinery, Campbell says. Slot mulching is usually done right after harvest when there is an ample supply of straw, he adds.

A mulcher using Saxton's concept is now being manufactured in Oregon by a private firm. The commercial machine uses a 4-foot-diameter trenching wheel to make 4-inch-wide by 10-inch-deep slots. A V-shaped arrangement of tined conveyor belts draws straw to a central hopper where it is compacted into the trench.

Although designed for soil conditions and rainfall patterns in the Pacific Northwest, slot mulching can be useful wherever hilly land is farmed, Saxton believes. The mulcher's knack of disposing of excess straw may also benefit farmers who need a clean seedbed to plant a second crop immediately after harvesting the first, he says.

Keith A. Saxton is located at ARS Land Management and Water Conservation Research, Smith Engineering Bldg., Rm. 255, Washington State University, Pullman, Wash. 99164.—**Howard Sherman,** Albany, Calif., and **Lloyd McLaughlin,** Beltsville, Md. ■

New High-Speed Spinner Boosts Yarnmaking Efficiency

An experimental high-speed electrostatic spinner could allow textile manufacturers to produce high-quality cotton yarn at faster rates. The prototype spinner was recently developed under an ARS contract by researchers at the Battelle Memorial Institute's Laboratories at Columbus, Ohio.

"Conventional ring-spinning methods," says Robert B. Reif, who heads the Battelle research team, "are limited in speed, while conventional rotor-spinning is limited to making low-count, heavy yarns."

The new process uses electrical fields to guide individual fibers into the tail of the newly formed yarn, which is twisted as it is being formed. Special features stabilize the tail and control stray fibers—problems that caused electrostatic spinning to be discarded as a commercial process in the 1970's. Battelle holds a patent on the process.

In carrying out their study, the researchers analyzed data on all open-end spinning processes developed during the last 30 years. They then evaluated various experimental electrostatic spinning concepts designed to eliminate known problems that limit the current open-end spinning processes. Each process was demonstrated at low speed, and, based on the results, researchers selected the technique with the greatest potential for being developed into a high-speed process for making yarn of commercial value.

The system is now being used to make yarn samples for evaluation by Kearny Q. Robert, Jr., and other researchers at ARS's Southern Regional Research Center. They are also preparing a production run to test the properties of fabrics made from yarn spun by this new machine and to compare them with fabrics made from conventionally-spun yarns.

Kearny Q. Robert, Jr., is located at the Southern Regional Research Center, 1100 Robert E. Lee Blvd., New Orleans, La. 70179. For patent information, contact Arthur B. Westerman, Battelle Development Corp., 505 King Ave., Columbus, Ohio 43201.—**Jeff Botti,** news bureau specialist, Battelle's Columbus Laboratories, Ohio. ■

The seedy but tasty 'Foster' grapefruit (left) is valuable primarily for juice. Made seedless by gamma irradiation (right), it should now appeal to the fresh fruit market as well. (PN-7137)

Gamma Rays Produce Superior Seedless Citrus

Orange and grapefruit seeds and cuttings exposed to gamma rays in the early 1970's have produced trees that bear fruit superior to that now on the market.

According to C. Jack Hearn, the geneticist who developed the trees, consumers are deprived of some excellent citrus because, for most people, the fruits contain too many seeds to make easy eating. But in flavor, aroma, color, juiciness, and size these varieties outclass many oranges and grapefruit sold in stores.

Using gamma irradiation, Hearn has created "commercially seedless" forms of the 'Pineapple' orange, which, he says, are superior to the market variety. He has also created fresh-market versions of the 'Foster' grapefruit, "the best early ripening red grapefruit I know," he says, and of the 'Duncan' grapefruit, a white variety that is "the standard of quality for all grapefruit."

Because of seediness, these varieties are presently used only to make juice and other products. Citrus fruits are considered commercially seedless if they contain fewer than 10 seeds. By contrast, a normal 'Pineapple' orange may contain more than 25 seeds and the grapefruit varieties, more than 50 seeds.

Explaining the use of radiation, Hearn says: "It isn't possible to interbreed oranges or grapefruit because both reproduce asexually; the seeds simply develop embryos without fertilization.

"It has long been known that radiation causes mutations in plants and animals. I thought that seediness might well be altered by exposing enough seeds or budwood to higher than natural doses of gamma radiation."

Enough is the key word. As Hearn explains: "Irradiation is nonselective. I got all kinds of unwanted variations in addition to the characteristics I was seeking."

Besides being superior fresh-market fruit, Hearn's creations are as suitable for processing as their seedy ancestors. "The seedless types," Hearn says, "would give growers a marketing option—they could sell on the fresh or processing market, whichever would be more advantageous. In some instances, these types would fill in fresh-market gaps between early and late fruit."

C. Jack Hearn is located at the U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, Fla. 32803.—**David Pyrah,** New Orleans, La. ■

Ultrasonic Pest Repellers Fail Tests

Do ultrasonic-sound contraptions drive insect pests off the premises as advertised?

The answer is no, according to tests conducted at the Insects Affecting Man and Animals Research Laboratory, Gainesville, Fla. Scientists tested two brands for their effectiveness against German cockroaches, *Blatella germanica,* and two species of biting mosquitoes, *Aedes aegypti* and *Anopheles quadrimaculatus.*

The ultrasonic waves generated by the gadgets neither drove the insects away nor stopped the mosquitoes from biting, according to entomologist Carl E. Schreck, the principal investigator. "In one test," Schreck said, "*Aedes aegypti* mosquitoes actually bit more frequently when one of the machines was turned on than when it was turned off."

The devices were tested at the request of the U.S. Postal Service, which had received complaints about them from the public. Numerous such devices are on the market. The manufacturers generally claim that the ultrasonic waves (sounds not audible to the human ear) generated by the machines repel a variety of pests, including roaches, flies, mosquitoes, rats, and mice, within a certain range. They also claim that the waves are not harmful to humans or household pets.

"The devices we tested," Schreck said, "were not entirely ultrasonic. The lowest of the three frequencies on each machine was clearly audible. And the sound level—the decibels—produced by one device exceeded the safety level permitted by the Occupational Safety and Health Act."

Is there any indication that ultrasound is effective against any household pest? "We did not find a shred of evidence to support such a claim," Schreck said.

Carl E. Schreck is located at the Insects Affecting Man and Animals Research Laboratory, P.O. Box 14565, Gainesville, Fla. 32604.—**David Pyrah,** New Orleans, La.

Safflower Fields for Weed Control

Safflower—a minor crop grown for its oil content—might help farmers and ranchers control weeds on fallowed fields and protect soil from wind erosion on the Great Plains.

Weeds can become a real problem on lands used for wheat-fallow cropping. Under this system farmers grow wheat one year and then let the land idle for the following year to build up enough moisture for another wheat crop the third year.

The best herbicides for controlling weeds on fallowed land are longacting and have the potential to harm the wheat crop that follows.

Safflower is more tolerant of these particular herbicides. Soil scientist Francis Siddoway got good weed control on fallow lands by applying between 1 and 2 pints of glyphosate per acre to control grassy weeds and 2 pints of 2,4-D to control broadleaf weeds.

The remaining stubble after the safflower harvest was sufficient for good control of wind erosion. Although safflower only produced slightly more than 500 pounds of straw per acre, it was enough to prevent wind erosion in the spring of 1981—one of the windiest and most soil-damaging periods ever in eastern Montana.

Wheat produces up to 3,000 pounds of straw per acre and provides good erosion control when the straw remains upright, Siddoway says.

"Growing safflower on fallowed land would still provide some income while breaking weed invasions. It hasn't been proven, but I think a rotation to safflower every few years could help keep diseases that strike wheat under control. This holds true for other crops grown in rotation with small grains," says Siddoway.

Francis Siddoway, now retired, was located at the Northern Plains Soil and Water Research Center, P.O. Box 1109, Sidney, Mont. 59270.—**Dennis Senft,** Albany, Calif. ■

Fourwing Saltbush—Not Just a Range Weed

Fourwing saltbush (*Atriplex canescens*), present in moderate to fair amounts on many sandy and floodplain areas of the central Great Plains, is more important in the diets of grazing cattle than previously thought.

On both winter and summer pastures where this type of saltbush was abundant, cattle preferred this species over most other herbs and shrubs. The bush is moderately high in protein, phosphorus, and calcium, especially during winter months. (See table.)

Fourwing saltbush was considered by some to be just another range weed. However, studies conducted by ARS and Colorado State University's Agricultural Experiment Station, Fort Collins, show that this plant is a major constituent in cattle diets.

"Fourwing saltbush was the major forage species that cattle ate during the winter, ranging from 13 percent during November to 55 percent during March," says ARS range scientist Marvin C. Shoop.

Comparison of fourwing saltbush and grasses in meeting needs of pregnant cows

Nutrient	Needs	Fourwing saltbush	Grasses
Crude protein (%)	7.5	7.0	3.0
Phosphorus (%)	0.19	0.08	0.06
Carotene (mg/lb)	3.0	3.6	0.4
Metabolizable energy (Mcal/lb)	0.85	0.7	0.9

Consumption declined slightly during April, then the plant became an average diet constituent during June. During July, the cattle didn't eat any of it, yet in August, it was again the major diet component.

On adjacent pastures with sparse amounts of fourwing saltbush, sand dropseed (*Sporobolus cryptandrus*) was the most important diet component during winter, while blue grama (*Bouteloua gracilis*) was during summer.

"We are now conducting research to determine if pastures with abundant amounts of fourwing saltbush might be used to provide a greater portion of the protein needs of cattle in the region," says Shoop.

Cow grazing on fourwing saltbush. (1184X1688-5A)

The plant may also prove useful for revegetating stripmine spoils. Laboratory studies at Mandan, N. Dak., showed that fourwing saltbush germinated better in solutions of sodium and magnesium sulfate than in distilled water. These salts are found in soil and mining spoils in the northern Great Plains, says range scientist Ronald E. Ries. He and agronomist Lenat Hofmann studied eight forage species for revegetation. Canby bluegrass and thickspike wheatgrass also thrived in the sulfate solutions.

Marvin C. Shoop is located at the Crops Research Laboratory, Colorado State University, Fort Collins, Colo. 80523. Ronald E. Ries is at the Northern Great Plains Research Laboratory, P.O. Box 459, Mandan, N. Dak. 58554.—**Dennis Senft,** Albany, Calif., and **Betty Solomon,** Peoria, Ill. ■

Patents

Patents is a regular feature of *Agricultural Research* magazine. Its purpose is to make the more than 1,200 patented inventions of the U.S. Department of Agriculture better known to businesses and individuals that might benefit from using them.

If you are interested in applying to obtain the license on a patent, write to the following address for an application form and information on license provisions and licensee responsibilities: Patents Office, USDA-ARS, Office of the Administrator, Rm. 323, Bldg. 003, Beltsville Agricultural Research Center—West, Beltsville, Md. 20705.

Biocontrol for Major Bean Disease

A special strain of the ubiquitous bacterium, *Bacillus subtilis,* is effective in inhibiting and controlling all known races of the bean rust pathogen, *Uromyces appendiculatus,* and may be effective against other plant pathogens. Bean rust is a major disease of dry and snap beans worldwide—causing very high yield and monetary losses in the United States alone.

The bacterium itself or a heat-stable culture extract can be applied as a spray or an aerosol. Such a product will help to improve the environment by reducing the use of synthetic fungicides, which are increasingly expensive to the farmer and not always effective.

Manufacturers of farm chemicals, particularly those producing biocontrol products, will want to learn more about this pending patent.

For further technical information, contact Con J. Baker, Rm. 201, Bldg. 004, Beltsville Agricultural Research Center—West, Beltsville, Md. 20705. **Patent Application Serial No. 539,907, "Control of Bean Rust With *Bacillus subtilis*."**

Cockroach Repellents

Cockroaches abhor being in the public eye, but they would rather die out in the open than enter a dark container with food and water that has been sprayed with one of several novel repellents. Many of the compounds completely repelled the irrepressible German cockroach, *Blatella germanica,* for prolonged periods.

A repellent could be used alone or with other control methods in buildings, transportation systems, equipment, food and drink vending machines, and many other areas. It would be particularly useful where toxicants cannot be used. It also can curtail the redistribution of cockroaches if used to treat shipping cartons, grocery bags, and other movable containers.

Manufacturers of organic chemicals should take note of these new repellents—all amides. They are readily synthesized from commercially available intermediates, and their market could be worldwide.

For further technical information, contact Terrence P. McGovern, Rm. 301, Bldg. 007, Beltsville Agricultural Research Center—West, Beltsville, Md. 20705. **Patent Application Serial Nos. 625,329 and 625,266, "Cockroach Repellents," and Patent Application Serial No. 625,328, "Insect Repellents."**

Promising Nontoxic Food Preservatives

Food processors will be interested in potent new inhibitors of the botulism-causing bacterium, *Clostridium botulinum.* Some of them repress bacterial growth at one-thousandth the concentration of sodium nitrite. Because the compounds are essentially nontoxic, they will make excellent replacements for sodium nitrite and ethlyene dibromide (EDB)—both known to be carcinogenic.

EDB has been banned as a preservative in grains in the United States, and sodium nitrite has been banned in several foreign countries. Capital investment for producing the new compounds—esters of maleic and fumaric acids—is estimated at less than $10,000, and the market could encompass all countries producing grain and meat products.

For further technical information, contact Michael Dymicky, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, Pa. 19118. **Patent Application Serial No. 611,042, "Anticlostridial Agents."**

Controlling Stored-Grain Pests Without Pesticides

Stored-grain insects are highly attracted to an inexpensive cardboard trap baited with a nontoxic food lure. The corregated cardboard provides a natural hiding place for these covert pests, and the lure—a mixture of savory grain oils and mineral oil—provides a pitfall in which the insects suffocate.

The trap attracts both adults and larvae of the beetles, weevils, and other pest insects, but can be readily tailored to capture a narrow range of species by adding a pheromone specific to that species. (For more information, look under "Caught in the Tender Trap," p. 9.) It is safe and highly effective in detecting these insects in large granaries, warehouses, farm storages, ships, and kitchens and should be useful in controlling low insect populations.

For further technical information, contact Wendell E. Burkholder, 537 Russell Laboratories, Dept. of Entomology, University of Wisconsin, Madison, Wis. 53706. **Patent Application Serial No. 06/610,949, "Suffocation-Type Insect Trap With Pitfall and Attractant."**